EUV Exposure of ETS Components

M. Malinowski[1], L. Klebanoff[1], M. Clift[1], T. Johnson[1], P. Grunow[1],
C. Steinhaus[1], B.Long[1], P. Dentinger[1], P. Spence[1],
M. Wedowski[2], P. Mirkarimi[2], C. Montcalm[2], S. Bosson[2]
U. Kleineberg[3], E. Gullikson[3]
[1]Sandia National Laboratories, Livermore, CA 94551, USA
[2]Lawrence Livermore National Laboratory, University of California, Livermore, CA 94551, USA
[3]Center for X-Ray Optics, Ernest Orlando Lawrence Berkeley National Laboratory,
University of California, Berkeley, California 94720, USA

INTRODUCTION

The Engineering Test Stand (ETS) is an advanced, prototypical lithography tool being developed in the EUVL (Extreme Ultraviolet Lithography) Program. In the ETS there are many components whose responses to prolonged exposures of EUV radiation must be determined. Such exposure responses include the effects of residual gases on multilayer mirror (MLM) reflectivity, multilayer mirror stability, and gas desorption from resist-coated silicon wafers. During 1998 we completed a series of experiments to help answer some of these important ETS/EUV exposure issues. This abstract outlines the work that was done. Details of the results obtained are not given because of their business-sensitive nature in the EUVL Program.

EXPERIMENTAL SYSTEM

All experimental runs were performed using a demountable, ultrahigh vacuum chamber that could be attached to a port on the existing EUV Interferometry chamber on Beamline 12.0.1.2. Our chamber had a movable, 100 μm diameter aperture located at the EUV beam crossover point downstream from the Interferometry chamber. This aperture provided vacuum isolation from the upstream beamline. This isolation was important when doing simultaneous EUV + gas exposures of ETS components, since it allowed the use of high exposure pressures (up to 10^{-4} Torr) in the experimental exposure chamber while keeping the Interferometry chamber at its normal operating pressure of ~ 10^{-8} Torr. The experimental chamber was totally dry-pumped and had a residual gas analyzer (RGA), ion gauge, gas inlet system, and photodiode for measuring EUV powers. A removable end flange on the chamber supported all the internal sample manipulators and specialized diagnostic equipment. The internal fixturing attached to this flange was changed to perform different experiments. An existing, upstream grating monochrometer or "blank" reflecting surface on Beamline 12.0 was used to select either a single wavelength band or the complete undulator spectrum as the input EUV beam. As measured by the *in-situ* photodiode, energy fluxes in excess of ~ 10 mW/mm^2 were achieved in sample positions in the experimental chamber. The base pressure in the system after an overnight bake was approximately 1 x 10^{-9} Torr with hydrogen being the dominant background gas.

EXPERIMENTS

I. Mo/Si Multilayer Mirror Contamination

Several experimental runs were devoted to determining the effects of exposing Mo/Si multilayer mirrors (40 bilayer pairs, Si capping layer, maximum initial peak reflectivity of ~67.8% at 92.24 eV) to EUV in the presence of different, low molecular weight gases, some of which contained carbon. Exposure pressures up to ~ 10^{-4} Torr and nominal beam powers of 10 mW/mm^2 at 92.3 eV (~1% bandwidth) were used. The change in multilayer mirror reflectivity was measured *in-situ* with the photodiode and *ex-situ* sputter-through

Auger Electron Spectroscopy (AES) was used to help determine the change in the near surface composition of the mirrors. The possible effects of sample beam heating and theoretical change in mirror reflectivity with contamination were modeled.

II. Mo/Be EUV Exposure

An extended experimental run was made with Mo/Be multilayer mirrors mounted in a position in the experimental chamber, which maximized EUV energy flux to the samples. These data runs were performed to help determine the radiation stability of the mirrors and the "raw" undulator power reflecting off the blank was used. The reflectivities of the mirror samples before and after the exposures were measured on the Calibration and Standards Beamline 6.3.2. Sputter-through AES of all samples was also performed.

III. Filter EUV Exposure

The radiation hardness of EUV filters was also studied. Both "raw" undulator radiation and EUV at 92.3 eV (~1% bandwidth) were used for the exposures. Both the EUV transmission and physical integrity of the test filters were measured before and after exposures. The surface compositions of all samples were determined by AES.

IV. Resist Desorption

The EUV-induced desorption of three different resists was studied over an energy flux range of ~ 0.1 to 1.5 mW/mm^2 with EUV light at 92.3 eV. The pressures and residual gas spectra for all resists were detected during all desorptions. Desorptions were performed such that the residual gas analyzer could be operated in both line-of-sight and non line-of-sight modes. An *in-situ* calibration of the mass spectrometer response together with measurement of the desorption area after the runs permitted quantitative desorption rates to be determined. Within experimental accuracy, it was found that the peak desorption pressures were proportional to energy flux for each resist.

SUMMARY

A wide range of applied, EUV exposure experiments for the EUVL Program were performed on Beamline 12.0.1.2. These experiments have provided data essential for the planning and refinement of optical components and operating procedures for the ETS.

ACKNOWLEDGMENTS

Thanks especially to Ken Goldberg, Patrick Naulleau and Paul Denham for their help in interfacing our experiment to their EUV Interferometry System and providing critical assistance in making Beamline 12.0.1.2 work. We are also indebted to other CXRO personnel including, but not limited to, Phil Batson, Frank Zucca, and Kevin Bradley and his machine shop personnel.

[1]This work, performed at Sandia National Laboratories and at the Advanced Light Source, Lawrence Berkeley National Laboratories, was supported by the Extreme Ultraviolet Limited Liability Company (EUV LLC) and by the U. S. Department of Energy under contract DE-AC04-94AL85000.

[2]This work was performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under Contract No. W-7405-ENG-8. Funding was provided by the Extreme Ultraviolet Limited Liability Company (EUV LLC) under a Cooperative Research and Development Agreement

Principal investigator: M. E. Malinowski, Sandia National Laboratories, Livermore, CA. Email: memalin@sandia.gov. Telephone: 925-294-2069.